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Technical Note 5-63

VISCOUS-DAMPING MECHANISMS AS APPLIED TO FOUR-INCH ROCKET LAUNCHER MOUNT

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HUMAN ENGINEERING LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

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ABSTRACT

This report describes the development of a lightweight, variable, viscous-damping mechanism for a rocket launcher mount. This development is based on the Human Engineering Laboratories' recent demonstration of the advantages and torsional rate parameters that viscous damping offers in tracking moving targets with a "free" mount. A "free" mount is defined as one which a single man can move simultaneously in elevation and azimuth without using handwheels or mechanical power.

The chief advantage of a damping mechanism lies in it's ability to provide the gunner's muscular efforts with a smooth controlled resistance. Such a resistance reduces the conflict between the gunner's muscular coordination and the inert'al characteristics of the rotating launcher. The gunner is then much less likely to show high-frequency alternation between leading and following a moving target.

CONTENTS

VISCOUS-DAMPING MECHANISMS AS APPLIED TO FOUR-INCH ROCKET LAUNCHER MOUNT

BACKGROUND

The mechanisms described in this report were developed while designing a working mock-up of a lightweight four-inch rocket launcher, mount, and ammunition-loading system according to concept requirements.

The concept specifications allowed a maximum gross weight of 25 lbs. for the mount, including the azimuth and elevation damping system. The subject mount was designed and built within 20 lbs., and, with additional product engineering effort, a further weight reduction could be realized.

The various approaches to the problem of effective, practical damping, with their respective advantages and disadvantages, are listed below:

a. Friction brake device -- A mechanism employing the principle of brake drum and shoe, although very simple in concept, had the disadvantage of high static-to-dynamic frictional coefficient, hence the transition from condition of rest to motion was erratic.

b. Hydraulic drum containing stator and rotor vanes, similar to those in a turbine -- Although disadvantage of friction device was overcome, this system presented disadvantages of pulsating reaction, high cost, excessive weight, and excessive bulk.

c. Rotating discs or cylinders interspersed with high viscosity fluid -- This system proved exceptionally smooth; however, to obtain the features of variable torque along with the relatively high maximum torque required, a heavy, space-consuming device was required.

To overcome these disadvantages, and to incorporate the added feature of fast automatic reduction of torque for rapid traverse, the subject design was developed.

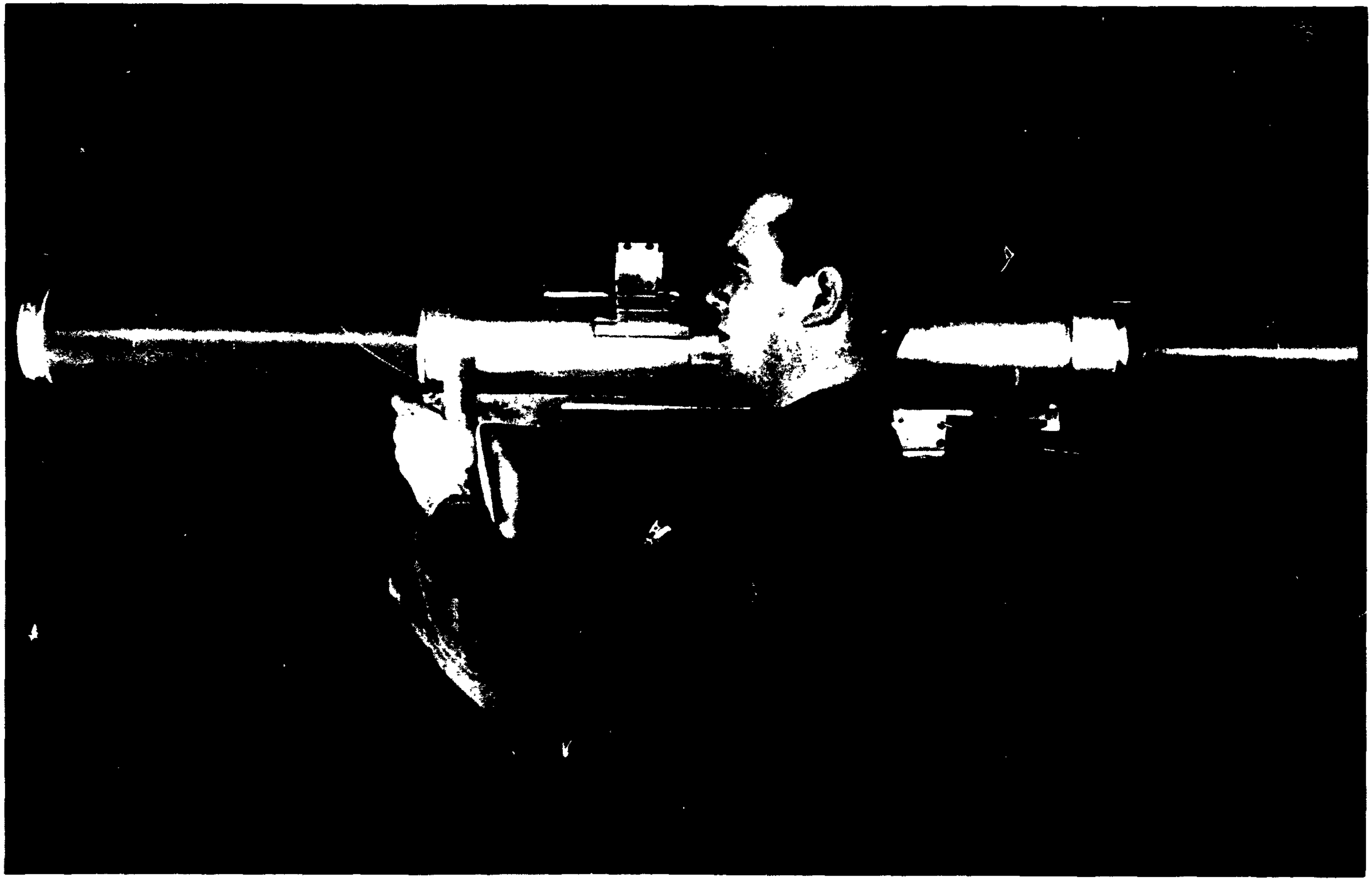

Fig. 1. ROCKET LAUNCHER -- SHOULDER FIRED

To minimize the factors of bulk and weight, a positive-displacement hydraulic system was built into the structural members of the mount. One of the "A" frames supporting the trunnions was used for the elevation damper, while the base supporting the "A" frames and the azimuth pintle contained the azimuth damper and fast-traverse device. (No fast-traverse device was deemed necessary for the elevating mechanism, since it traveled through an arc of only 30 degrees.)

Both elevation and azimuth dampers are independently variable to compensate for thermal changes and to accommodate the individual gunner's "feel".

It is conceivable that future mechanisms will contain automatic thermal compensators and will be factory-adjusted for torsional rate based on rates found to be optimal through human factors research. (Past research has placed the optimum rate at about .5 lb.ft/mil/sec for slightly heavier, but similar, systems.)

Each damper contains a replenisher to compensate for volumetric displacement of fluid due to thermal expansion and possible leakage.

Although the system will operate with high-viscosity oil or hydraulic fluid, a silicone fluid was selected because of its low viscosity variation due to thermal changes.

DESCRIPTION

The four-inch rocket launcher is designed to be fired as a shoulder weapon (Fig. 1), or as a mounted system (Fig. 2). The entire system consists of four major elements: ammunition, launcher, computer box, and mount. The total weight of the system is approximately 75 lbs.

When the mount is set up to fire as a mounted system, the computer box is cam-locked into the mount, and the launcher is then cam-locked into the computer box. The launcher can be elevated or depressed 15 degrees from horizontal and can be swung in azimuth plus or minus 165 degrees from nominal setting.

Since this report deals primarily with the damper system, the brief description above is intended for familiarization only.

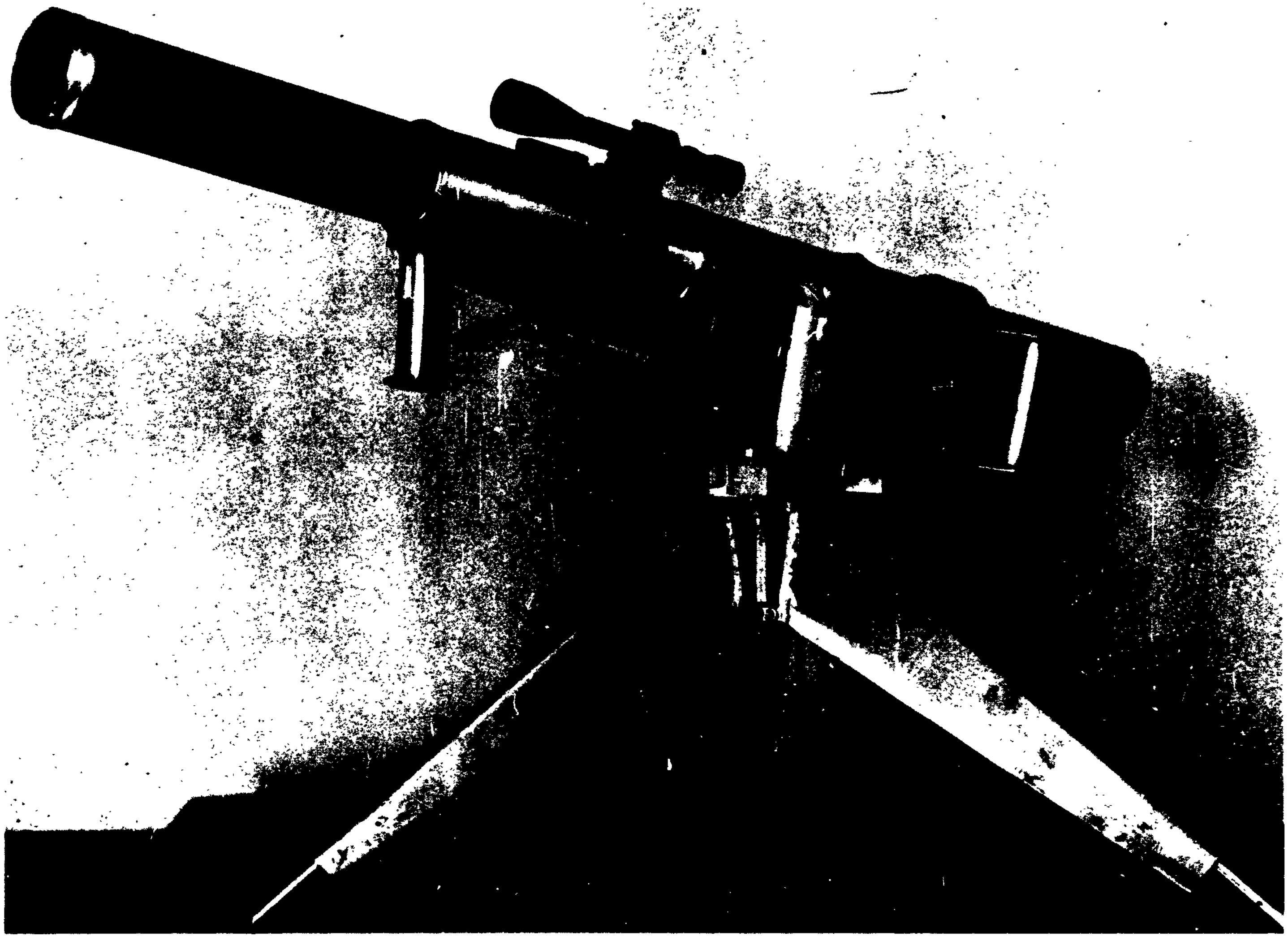

Fig. 2. ROCKET LAUNCHER -- GROUND MOUNTED

Elevation Damper (Fig. 3)

The elevation damper was built into the "A" frame adjacent to the gunner's position, so that the variable control knob would be readily accessible. A ribbed vane, rigidly pinned to the elevation trunnion shaft, rotates as the launcher moves in elevation. This vane's rotation, within the fluid-filled body of the "A" frame, forces the fluid from one side of the cavity to the other side through a by-pass valve. By varying the opening of the by-pass valve due to rotating the elevation torque control (Fig. 6-A), the torsional resistance can be adjusted to accommodate both viscosity variation due to temperature changes and the gunner's preference. Volumetric fluctuations of the fluid are accommodated by the replenisher, which is bolted to one side of the "A" frame and ported to the fluid chamber through a 1/16-inch-diameter orifice. It should be noted that the system is designed to normally operate at a pressure not exceeding one atmosphere; hence the fluid volume in the replenisher would not be affected by fluid pressure in the cavity. If, however, the launcher were moved rapidly enough to cause a fluid pressure to exceed one atmosphere, the time-orifice-viscosity relationship would prevent excessive volumetric change within the replenisher. The 1000-centistoke silicone fluid is sealed from the trunnion bearings by neoprene "O" rings. Clearances between vane and housing were held to .003 inch.

Azimuth Damper (Fig. 4)

The azimuth damper, built into the hollow interior of the horizontal base to which the "A" frames are bolted, contains the same design features, and functions according to the same principles, as the elevation damper. The notable differences are listed below:

a. A fluid of higher viscosity (3000-centistoke) was used because of the smaller hydraulic displacement per unit of rotation, as compared with the elevation damper.

b. Rotational arc is 330 degrees (165 degrees right or left of nominal setting).

c. The vane is fixed to the tripod pintle and the housing rotates about it, whereas, in the elevation mechanism, the housing was fixed and the vane rotated within it.

d. Mechanism contains automatic rapid-traverse feature described below (Fig. 5).

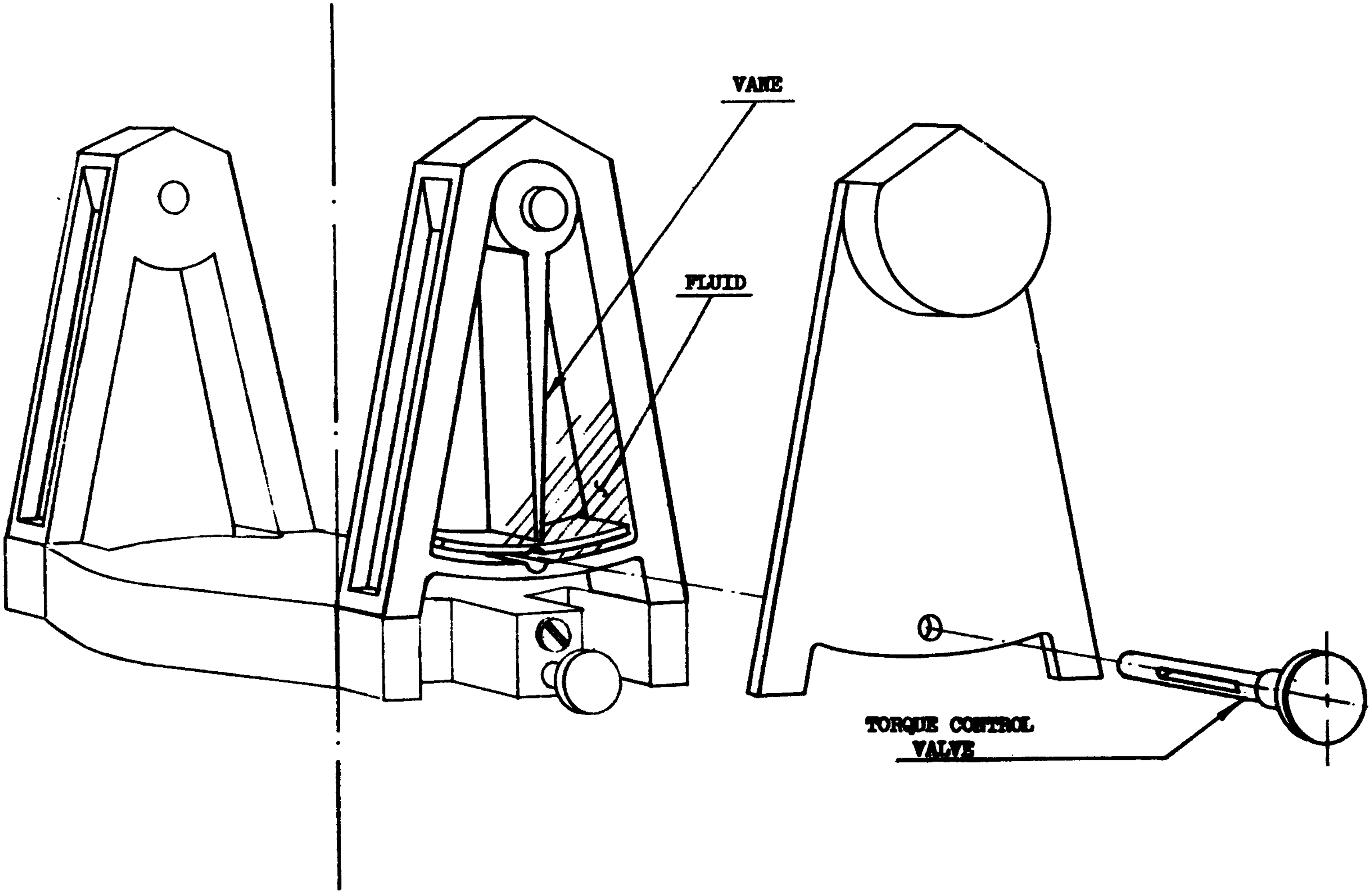

Fig. 3. ELEVATION DAMPER

Automatic Fast-Traverse Device (Fig. 5)

The mechanism built into the cavity of the base is a 30-degree partial sector containing two functional elements. One element is a variable by-pass similar to that used in the elevation mechanism and capable of being adjusted by the gunner. The other — a large-orifice relief valve — is normally closed under the action of a spring-loaded ball and valve-closing springs. If the gunner tries to traverse rapidly, fluid pressure will increase, making the relief valve open rapidly and stay open until rapid traverse ceases. The result is an instantaneous reduction of turning effort but without chatter or sponginess. The torque at which the relief valve opens can be adjusted externally by maintenance personnel; it should exceed the torque encountered during maximum tracking velocity.

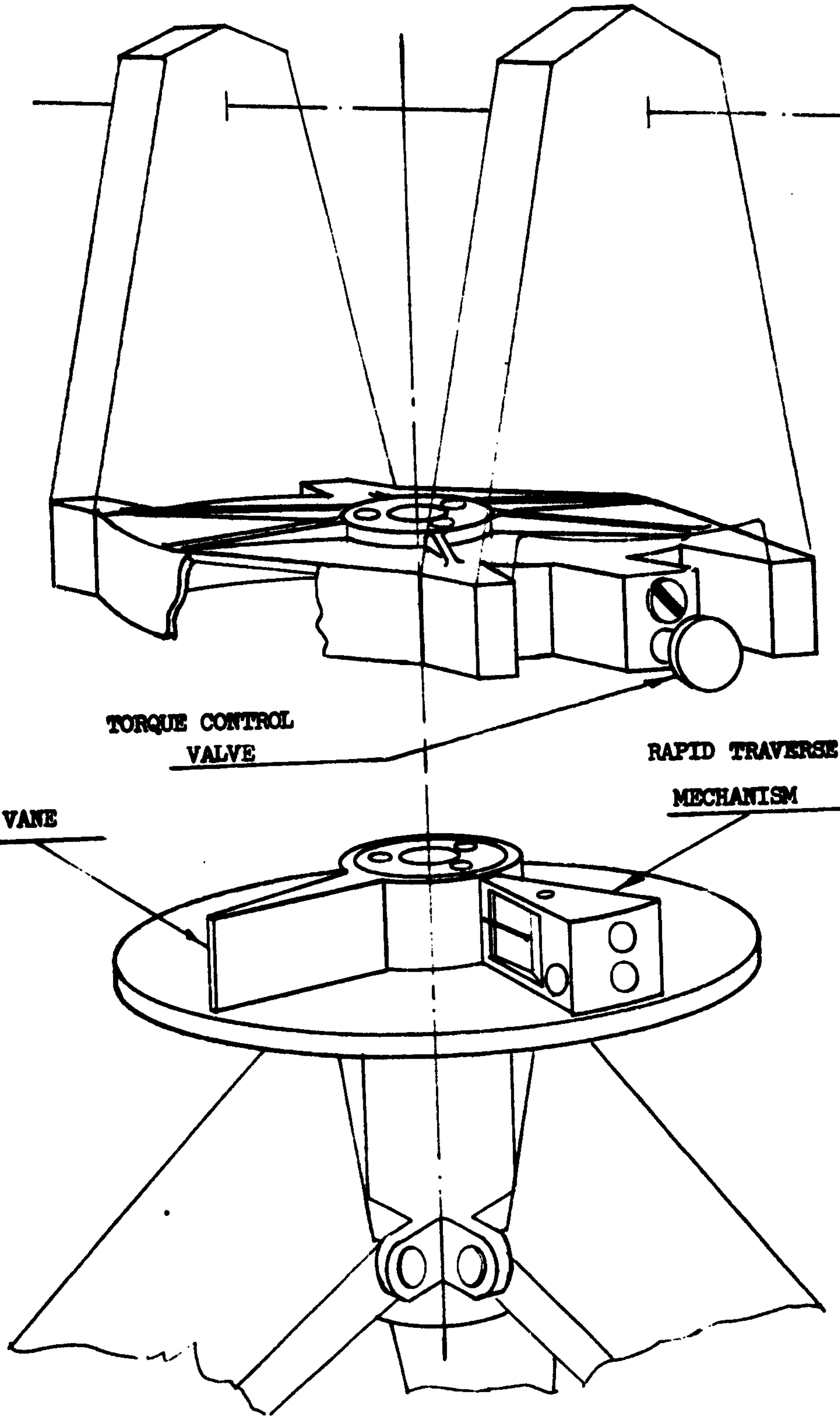

Fig. 4. AZIMUTH DAMPER

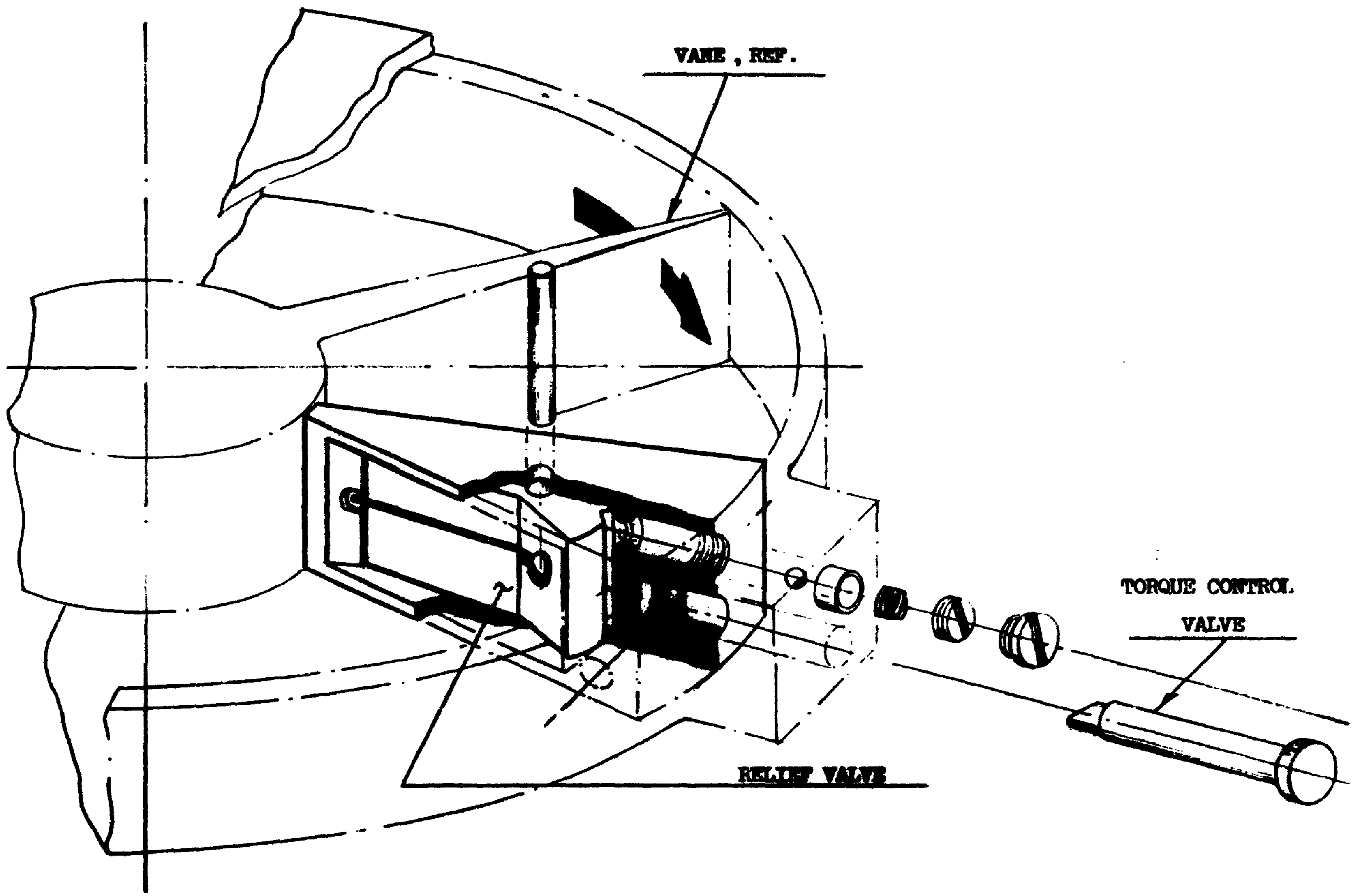

Fig. 5. AUTOMATIC FAST-TRAVERSE MECHANISM

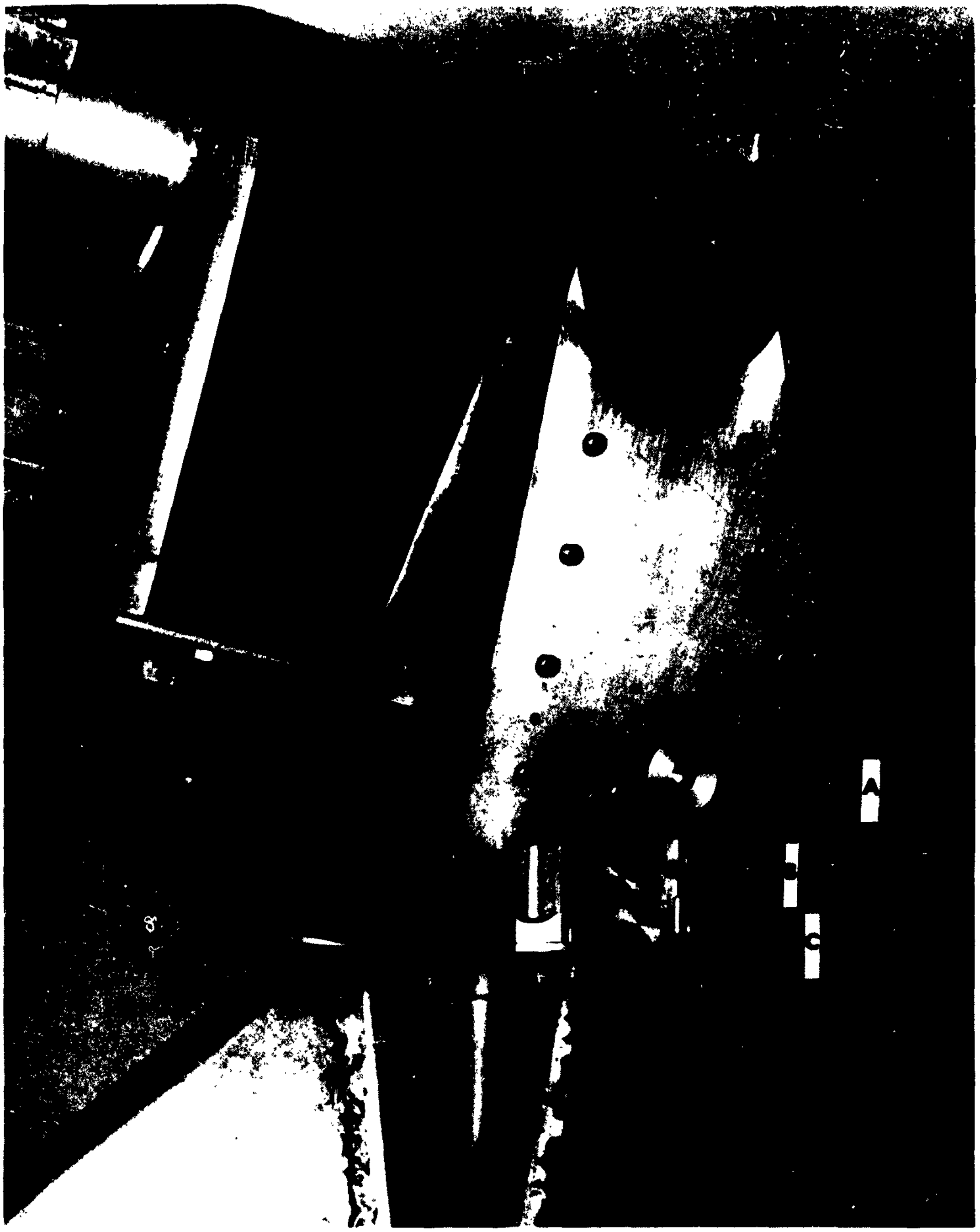

Fig. 6. TORQUE CONTROLS
(A. Elevation Torque Control, B. Fast-Traverse Control,
C. Traverse Torque Control).

CONCLUSION

The mock-up of the rocket launcher mount has clearly demonstrated the validity of the basic design features described, both from the engineering and human factors points of view. The chief advantages gained over previous designs are those of compactness, simplicity, and lightness, together with the added feature of instantaneous torque reduction for rapid traverse.

The disadvantage of this mount is that it cannot rotate through an angle of 360 degrees or more. While this limitation offers no problem in elevation, it is undesirable in azimuth. Tactical users would have to consider this limitation much the same as that of emplacing a gun or howitzer. Although this analogy is valid, it is less severe; a field piece can be swung only 20 to 30 degrees, while the subject mount can be swung 330 degrees.

At this time, no extensive testing or calibration has been completed, so no rate-versus-torque curves are yet available.

RECOMMENDATIONS

Future developments of viscous-damping mechanisms for rocket launcher mounts should consider such things as:

a. Further reduction of weight through redesign of shapes and sections, together with substitution of magnesium and fiberglass where practical.

b. It is conceivable that a missile system employing this mount would require rate information from the mount itself to achieve stable missile flight. When one is considering an electrically or hydraulically powered rate mount, this rate information is readily available from the gunner's input to the mount or turret. With a damping system such as the one being discussed here, this information is not easily available. However, if different gunners do not require different damping rates, and if compensators for thermal viscosity changes are included, then rate information might be obtained readily from a pressure transducer suitably located inside the damper.

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